



# An innovative method to assess suitability of Nitrate Directive measures for farm management



Annabelle Richard<sup>a,\*</sup>, Marion Casagrande<sup>b</sup>, Marie-Hélène Jeuffroy<sup>c</sup>, Christophe David<sup>a</sup>

<sup>a</sup> ISARA Lyon, Département Agroécologie et Environnement, Université de Lyon, 23 Rue Baldassini 69364 Lyon, France

<sup>b</sup> ITAB - Institut Technique de l'Agriculture Biologique, Ferme Expérimentale, 2485 Route des Pécolets, 26800 Etoile sur Rhône, France

<sup>c</sup> UMR Agronomie, INRA-AgroParisTech-Université Paris Saclay, Bâtiment EGER, 78 850 Thiverval-Grignon, France

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## ABSTRACT

Controlling groundwater diffuse pollution induced by agricultural practices remains a significant challenge and has been receiving strong attention in the European Union (EU) for the last 25 years. The EU's Nitrates Directive (91/676/EEC) and its associated Nitrate Vulnerable Zone (NVZ) legislation were recently revised in France in 2015, requiring farmers to adopt measures and then modify their agricultural practices to protect water resources. Yet these measures are not always implemented in an optimal way, thus limiting improvement of groundwater quality. Based on semi-directive interviews with 14 French farmers, we developed an innovative farm-scale method composed of four steps. First, we described how these farmers implemented Nitrate Directive measures. Second, we evaluated their impact on farm structure and third their consistency with farmer's strategy. Fourth, we assessed their suitability for farm management as an integrative analysis of the previous step. Through this approach, we identified 3 types of farm management. A group of "Beyond Regulation" composed of farmers for whom Nitrate Directive measures are suitable for their farm management. They optimally implement these measures to reduce pressure on groundwater quality. For the second group named "Soft Regulation-constraints", Nitrate Directive measures are less suitable for their farm management because they have another lucrative activity than cash crop production. This group could benefit from a redesign of the measures, changing from means- to result-oriented obligation in order to take into account the local conditions and also their farm management constraints. For the third group, denoted as "Strong Regulation-constraints", ND measures are not suitable for their farm management. The way they implement measures is usually not optimal to reduce pressure on groundwater quality. We suggest that, investing in an "action-learning" program for such farmers could make them understand the usefulness of this regulation and help them to make the measure implementation suitable for their farm management. This farm-scale method could be used further for water management stakeholders to (i) evaluate the suitability of measures from Water Policy for the diversity of farm management or (ii) design suitable measures for the diversity of farm management on a territory subjected to groundwater pollution issue.

## 1. Introduction

Groundwater is a major source of drinking water in Europe: therefore, its quality is of vital importance (Scheidleder, 1999). Water can be degraded through point source or diffuse pollution. Although point source pollution can often be identified and easily addressed, diffuse pollution is more difficult to overcome because it lacks a clearly defined point of entry and is associated with land uses (Macgregor and Warren, 2006). The most notable land use responsible for diffuse pollution is agriculture (Merrington et al., 2002). The shift towards greater intensification of agriculture since the 1960s, including the increased use

of fertiliser and greater specialisation of farms and regions, resulted in water quality degradation caused by nitrates and chemical inputs. Nitrates are one of the world's most widespread groundwater pollutants (Lopez et al., 2015).

There is worldwide consensus on eutrophication reduction. To reach this target, the European Union introduced a range of pollution control measures such as the 1991 Nitrate Directive (ND) (91/676/EEC). Under the ND, Nitrate Vulnerable Zones (NVZ) have been defined throughout Europe as either surface or groundwater in which the nitrate levels exceed or are likely to exceed 50 mg/L from agricultural sources. The impact of the ND depends upon the interpretation of the requirements

\* Corresponding author.

E-mail address: [arichard@isara.fr](mailto:arichard@isara.fr) (A. Richard).

by Member States (Andersson et al., 2012; Liefferink et al., 2011), especially the interpretation of ‘vulnerable,’ because this affects the extent of the territory designated and subject to mandatory requirements.

In France, NVZ were revised in 2015. The revision took place during litigation initiated by the European Commission against France for incorrect application of the ND, notably, for the insufficient surface areas designated as NVZ. Approximately 70%<sup>1</sup> of French farmland is considered vulnerable, mainly in areas where farming activity is highly intensive. In these zones, farmers must implement a set of measures defined in an action programme. This programme includes measures that limit the use of organic and mineral fertilisers (quantity and spatio-temporal limitations), and measures aimed at covering the soil during winter to prevent nitrate leaching and run-off during wet seasons. Despite the water policy, the nitrate pollution of groundwater resources, covering 64% of tap water, remains a major problem in France (Ifen, 2003).

Agronomic research at different scales has facilitated the understanding about why regulatory measures are only partially successful in terms of impact on groundwater quality (Brun, 2003; Oenema et al., 2009). At territorial scale, Gaigné (2012) demonstrated that the implementation of livestock regulation measures in France do not decrease the livestock spatial density and, consequently, the nitrate leaching from farmyard manure. At a field scale, Deneufbourg et al. (2010) studied in Hesbaye (Belgium), with a lysimeter, the efficiency of two measures from ND (*fertilisation planning* and *soil sampling*) to recover groundwater quality. The study noted that when soil sampling for nitrate content analysis is performed too soon in the winter season, an underestimation of the nitrate soil content may occur, leading to an overestimation of the fertilisation recommendation. Thus, the *soil sampling* measure can negatively impact groundwater quality depending on how the farmers implement it.

At farm scale, several papers demonstrated that numerous European farmers remain unconvinced about the appropriateness of the ND measures to balance farm management and environmental benefits (Barnes et al., 2009, 2011; Buckley, 2012; Macgregor and Warren, 2006; Smith et al., 2007; Widdison et al., 2004). Chantre et al. (2016) mentioned that regulatory measures are not always agronomically consistent or compatible with farmers’ management (Kuhfuss, 2013; Menard et al., 2014), and their positive impact is, thus, not ensured.

The objective of our study is to analyse the diversity in the implementation of the ND’s measures on farms and identify the determinants of this diversity at farm scale. This diversity is linked to their level of accordance of ND’s measures with farm management and induces different effects on groundwater quality pressure. We assume that if the ND’s measures are in accordance with farm management, firstly, these measures would be implemented to effectively reduce pressure on groundwater quality (optimal manner). Secondly, the measures would be implemented long term even if a regulation’s contents change (perennial manner). Thus, these results would be discussed to identify the conditions for optimal and perennial implementation of measures within farm management.

This study addresses three questions: (1) What is the diversity in the implementation of the ND’s measures within farms? (2) Are the approaches to implementing the ND’s measures suitable for farm management?, (3) What could be the conditions for optimising the implementation of measures to reduce pressure on groundwater quality considering the diversity of farm management?

This work is based on a survey campaign conducted in 2016 on 14 farms in the NVZ in southeastern France (45°54′ north, 4°46′ east). We developed an analytical framework to assess the suitability of the ND’s

measures for farm management. Through this in-depth study of the implementation of the measures, we drew recommendations to improve the implementation of water protection measures. Our study aims to complement the literature by providing a farm scale evaluation of water policy with respect to target achievement, effectiveness, and sustainability.

## 2. Material and method

### 2.1. Case study

This study was conducted in the north of Lyon (45°54′ north, 4°46′ east) (Fig. 1a.), in eight municipalities within the NVZ, since 1997 or 2012 (Fig. 1b.). Cash crops represent most of the land occupation in these municipalities, with corn as the main crop.

This study was based on qualitative semi-structured interviews with farmers. Farms were chosen with the aim of covering a diversity of farm management, including a diversity of crops and livestock production (Table 1). We excluded fruit growers because they are not subjected to the ND and represent a small land occupation in the narrower protection zone (Fig. 1). Farmers were identified with the help of the technical adviser of the local cooperative. We also used a *snowball* method (farmers providing the contact information for a neighbouring farmer) (Thiétard, 2004, cited in Chantre, 2011) to sample farmers without a local cooperative contract and represent the spatial distribution of the farms. We interviewed fourteen farmers located in eight municipalities within the NVZ. These farmers cultivated 59% of the agricultural surfaces in this area (Table 1).

These farmers, located within the NVZ, must implement a set of measures defined by official authorities (Prefectorial Order n°14-88-5th Action Program of Rhône-Alpes region) to protect quality water from nitrate contamination (Table 2).

These measures are organised into three types according to content and requirements: (a) soil cover measures with *Cover*, *Mulch*, and *Strip*, (b) fertilisation measures with *PlanN*, *SoilN*, and *BalanceN*, and (c) spatio-temporal limitation measures with *Period*, *Stock*, and *Zone*.

### 2.2. Methodological approach

Aubry and Michel-Dounias (2006) developed a conceptual framework that distinguishes the changes of structure and strategy during the evolution of a farm management. Structure refers to crop management, rotation, materials, and human resources. Strategy refers to a combination of objectives targeted by the farmer where all the decision rules converge (Aubry and Michel-Dounias, 2006). We used this conceptual framework (i) to identify the determinants of the implementation of the ND’s measures and (ii) develop an analytical framework that assesses the suitability of the ND’s measures for farm management. The assessment of the suitability of the ND’s measures consists of evaluating how well these measures, once implemented, match the farm management. Based on this framework, we successively implemented four steps (Fig. 2):

- 1 We analysed how the farmers interpreted the ND’s measures, how they implemented them on their farm, and the rationales for these implementations.
- 2 We assessed the structural impact of the implementation of the ND’s measures by referring to structural modifications at the different levels of farm management.
- 3 We analysed the consistency of structural modifications with the farmer’s strategy.
- 4 We assessed the suitability of the ND’s measures for farm management as an integrative analysis of the previous steps.
- 5 Following the method used by Petit and Aubry (2016), a typology of farms, based on the percentage of ‘high’ suitability of the ND’s measures for their farm management (step 4) and their strategy

<sup>1</sup> Extract of the oral question n° 0954S of M. Jacques Mézard, published in JO Sénat of 04/12/2014, page 2667. Source: <https://www.senat.fr/questions/base/2014/qSEQ14120954S.html> - consulted on 09/12/2015.

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